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BIOLOGY AND IMMATURE STAGES OF THE RHODODENDRON GALL MIDGE, *CLINODIPLOSIS RHODODENDRI* FELT (DIPTERA: CECIDOMYIIDAE)

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Abstract.—*Clinodiplosis rhododendri* (Felt) is an occasionally serious pest of *Rhododendron catawbiense* hybrids grown in nurseries in the Northeast. Biological and ecological information is presented for the first time. Immature stages are described and illustrated. The larva was examined via scanning electron microscopy. The species is multivoltine, passes through 3 instars, and overwinters both in the soil and in flower buds as mature larvae. Larval aestivation and natural enemies are reported. Damage is described.

Key Words: Insecta, rhododendron gall midge, *Clinodiplosis rhododendri*, insect pest

Cecidomyiids, or gall midges, are a diverse group biologically and ecologically and are represented by more than 1200 species in North America. Although a few members of the family, such as the Hessian fly and alfalfa gall midge, are serious agricultural pests and well studied, most species have received very little attention.

White (1933) described damage caused by an unidentified gall midge on rhododendron. It was reported to cause considerable deformation of the leaves of *Rhododendron ponticum* L., *R. maximum* L., and hybrid varieties in nurseries. White also reported finding it on wild *R. maximum* in the Pocono mountains of Pennsylvania. Felt (1939) described the gall midge as a new species, *Giardomyia rhododendri*. Gagné (1973) placed *G. rhododendri* in the genus *Clinodiplosis* Kieffer. By our petition, the Entomological Society of America has approved the common name rhododendron gall midge. The gall midge is recognized in various books dealing with insect pests of ornamental plants, including those by Pirone (1978) and Westcott (1973). It is also recognized as a pest in several books on rhododendron culture such as those by Leach (1961), Bowers (1960), and Van Veen (1969).

MATERIALS AND METHODS

Site 1—a commercial nursery, East Hampton, NY; Site 2—a commercial nursery, Melville, NY. Emergence of adults from overwintering larvae was monitored with the aid of traps. Traps consisted of standard 6-in.-diameter white plastic flowerpots coated on the inside with Tanglefoot®. Traps were placed in an inverted position on the soil beneath branches of plants showing damage from the previous year. Twenty-eight traps were placed throughout two fields at Site 2 on 10 May 1980. Traps were checked by removing them and recording the number and sex of all gall midges present. Traps were checked nine times at intervals of 3–5 days from 19 May to 15 June.

Above-ground plant parts were examined with a 10× hand lens to ascertain oviposition sites. Eggs were collected with a moistened camel-hair brush and placed in

70% ethanol. Plant parts bearing eggs were removed and brought to the laboratory for further observation. Foliage bearing evidence of damage was removed and examined for larvae by carefully pulling it apart. The number of larvae, their size, color, location in the damaged tissue, and activity were noted. Larvae were transferred to 70% ethanol or a KAAD mixture with a moistened camel-hair brush. Infested foliage was removed and placed in paper bags for transport to the laboratory. Petioles of 10 infested leaves were sprayed with Tanglefoot® on 26 June 1979 at Site 1 to determine if mature larvae crawl down the plant to reach the soil for pupation. These petioles were checked on 2 July.

A random sample of 21 flower buds of the cultivar 'Nova Zembla', and 32 flower buds of 'Roseum Elegans', were taken on 10 April 1980 at Site 2 to ascertain whether mature larvae had overwintered in them, and whether there was a varietal preference. The buds were dissected on 17 April 1980 and the number and condition of mature larvae in them noted. Soil samples were taken on 10 May 1981 at Site 2 to determine the stage of development of overwintering larvae and their distribution within the soil. Fifteen saples were taken with an Oakfield® soil sampler from beneath plants that were heavily damaged the previous summer. Samples were divided into five depth intervals: 1–2 cm, 2–4 cm, 4–6 cm, 6–8 cm, and 8–10 cm.

Eggs on plant parts were observed with a dissecting microscope to determine color changes associated with development; location, orientation, and distribution on the host plant; and to aid in illustration. Eggs were placed directly in Euparal® on microscope slides for detailed observation and measurement. This was advantageous in that the minute, translucent eggs were difficult to recover from ethanol. An ocular micrometer was used to determine egg dimensions. A small camel-hair brush was used to manipulate and transfer eggs.

Larvae were easily removed from leaves by placing infested foliage in plastic bags; in a few hours the larvae vacated the leaves. Larvae crawling on the inner surface of the bags were then collected with a moistened camel-hair brush.

Larvae killed in KAAD were transferred to 95% ethanol after ½ hour. Some larvae were dehydrated in an alcohol series, cleared in a terpineol solution (Hood 1953), and mounted in Canada balsam on microscope slides for detailed observation. Other larvae were treated in cold 5% NaOH for 24 hours, dehydrated, cleared as above, and mounted in Canada balsam. Larval dimensions, including head capsuls widths, were determined with the aid of an ocular micrometer.

Larvae to be viewed with the scanning electron microscope were dehydrated in an alcohol series, washed twice in pure acetone, then transferred to small plastic capsules that had been perforated with a No. 00 insect pin. The larvae were critical-point dried using pure acetone. Each capsule was then gently opened and inverted over a mounting stub covered with double-sided tape. Larvae were positioned on the tape with the aid of a small camel-hair brush and then coated with 200–250 å of gold-palladium. All micrographs were made at 10 kV with an AMRAY 1000® SEM.

An estimate of the time required for mature larvae to complete development and emerge as adults was made by placing 20 mature larvae in a Syracuse watch glass containing moist sand and checking it daily for adult emergence. To more precisely determine the length of this period, mature larvae were placed in Thunderbird® No. 111 clear plastic cups of about 30 ml capacity containing sand moistened with distilled water. A single larva was placed in each cup after being examined for ectoparasites or any readily visible pathological condition. Each cup was covered with a plastic lid and placed in a rearing room (25°C, 75% RH). Cups were checked each morning and night starting on the ninth day. Forty cups were

Table 1. Dimensions (mm) of immature stages of *C. rhododendri*.

	Egg		Larva						Pupa	
			1st Instar		2nd Instar		3rd Instar			
	L	W	L	W	L	W	L	W	L	W
Mean	0.29	0.08	0.64	0.17	1.32	0.35	2.27	0.56	1.80	0.62
Maximum	0.30	0.09	1.17	0.47	2.10	0.51	3.03	0.76	2.10	0.76
Minimum	0.28	0.06	0.27	0.07	0.75	0.17	1.72	0.46	1.51	0.53
SD	0.01	0.01	0.27	0.08	0.29	0.08	0.29	0.08	0.21	0.08
n	25		24		47		37		7	

set up on 25 August 1979 with larvae collected at Site 1 the day before. Fifty larvae collected on 26 August 1980 at Site 2 were set up on 2 September 1980.

Cocoons were recovered from thoroughly dried soil samples with the aid of a No. 18 USA Standard Testing Sieve® (1.0 mm opening, Tyler equivalent = 16 mesh). Soil aggregates not passing the sieve were carefully broken apart under a dissecting microscope.

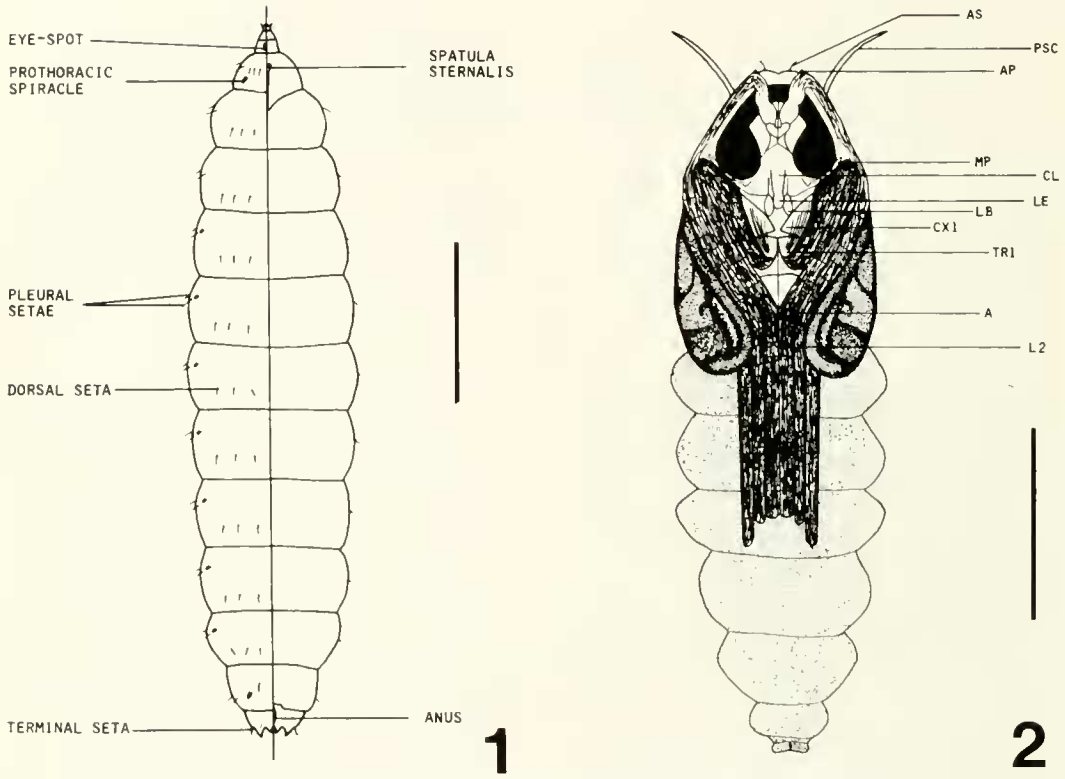
The longevity of adults was estimated by recording mortality for individuals emerging in the plastic cups. Sex was determined after death. Fecundity was measured by dissecting the ovaries of newly emerged gall midges and counting the number of eggs per female with the aid of a dissecting microscope. Cecidomyiids emerge from the pupal stage with their full complement of ova matured and ready for oviposition (Barnes 1946). Pairs of newly emerged adults were confined on swollen vegetative buds in the laboratory with the aid of small plastic cages (10 cm tall, 8 cm diam.). Unfortunately, all adults placed in cages on plants died within a few hours without having oviposited.

Description of Immature Stages

Felt (1939) published a description of the adult. Immature stages have not been previously described.

Egg ellipsoidal, nearly round in cross section, anterior end slightly wider than posterior; ca. 3 times longer than wide, 0.29 × 0.08 mm (Fig. 9; Table 1). Chorion smooth, shiny, transparent and unsculptured; sticky and resilient. Vitelline membrane visible, especially at posterior end. Newly deposited egg nearly colorless. As egg develops it becomes reddish-orange. A large, diffuse, reddish area appears slightly posteriad of center. Vitelline membrane becomes constricted at both ends of egg. Incipient segmentation evident as white patches appear along sides. A dark-red eyespot appears in the anterior eighth of egg during late stages of development.

Larva spindle-shaped with a distinct but minute head; ca. 3¾ times longer than wide, length varies from ca. 0.5 mm in first instar to ca. 2 mm at maturity (Figs. 1, 3, 4; Table 1). Larva creamy white throughout most of its development, becoming orange-yellow at maturity. Head capsule weakly sclerotized, with prognathous mouthparts (Fig. 5). Mouthparts consist of mandibles, maxillae, a labrum and labium (Fig. 6). Mandibles inserted internally. Papillae present on maxillae and labium; pits present on labrum. Antennae two-segmented, conical, conspicuous. Head separated from thorax by well-developed cervix. Dark-red eyespot present within cervix in all instars. Spiracles present on prothoracic segment and abdominal segments 1–8 of third-instar larva; those on prothoracic segment and eighth abdominal segment prominent. Spatula present on prothoracic venter of third-instar larva. Integument rugose (Figs. 3, 4). Rows of spinules prominent on venter of meso- and metathoracic segments and abdominal seg-



Figs. 1–2. *Clinodiplosis rhododendri*. 1, third-instar larva (dorsal and ventral views). 2, Pupa (A = antenna, AP = antennal process, AS = apical seta, CL = clypeus, CX1 = prothoracic coxa, LB = labella, LE = labrum-epipharynx, L2 = mesothoracic leg, MP = maxillary palp, PSC = prothoracic spiracular cornicle, TR1 = prothoracic trochanter). Scale bar represents 0.5 mm.

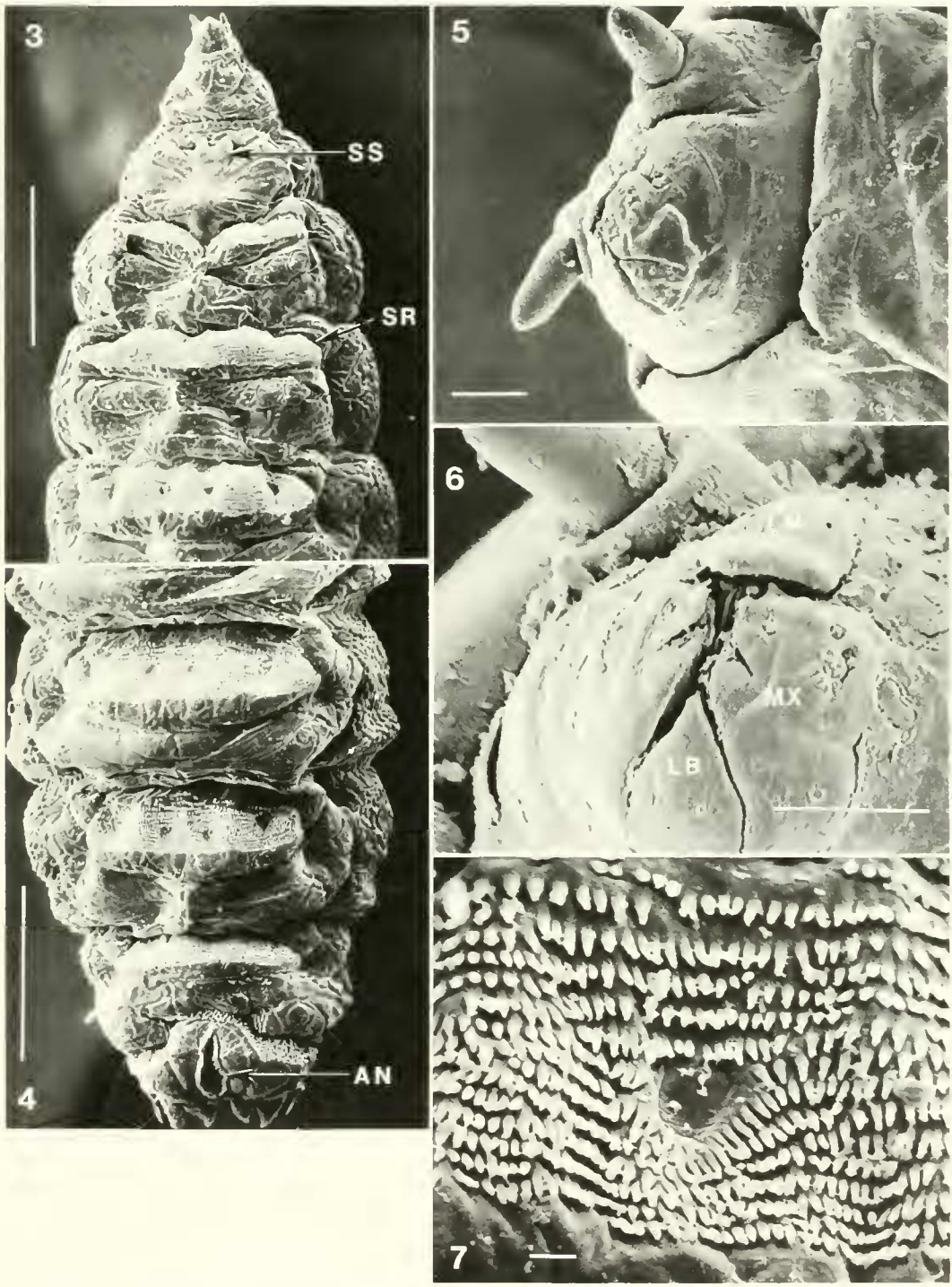
ments 1–9. Barren patches within spinule rows present on abdominal segments 1–7 (Fig. 7). Spinules surround anus. Six dorsal and 4 pleural setae present on each thoracic segment and on abdominal segments 1–7. Terminal segment with 8 papillae; 4 with setiform setae, 4 with corniform setae.

Pupa spindle-shaped, exarate (Fig. 2; Table 1). Teneral pupa orange-yellow. In mature pupa (pharate adult) eyes black, wings dark brown to black, legs and antennae dark yellow-brown, legs lighter distally. Abdomen retains larval color. Sclerotized process located on base of each antennal sheath. Apical seta situated mediad and posteriad to each process. Prothoracic spiracular cornicles prominent, curved outward, tapering. Abdomen 8-segmented; minute spiracles on segments 2–6. Prominent setulae present dorsally along anterior margins of segments 2–8.

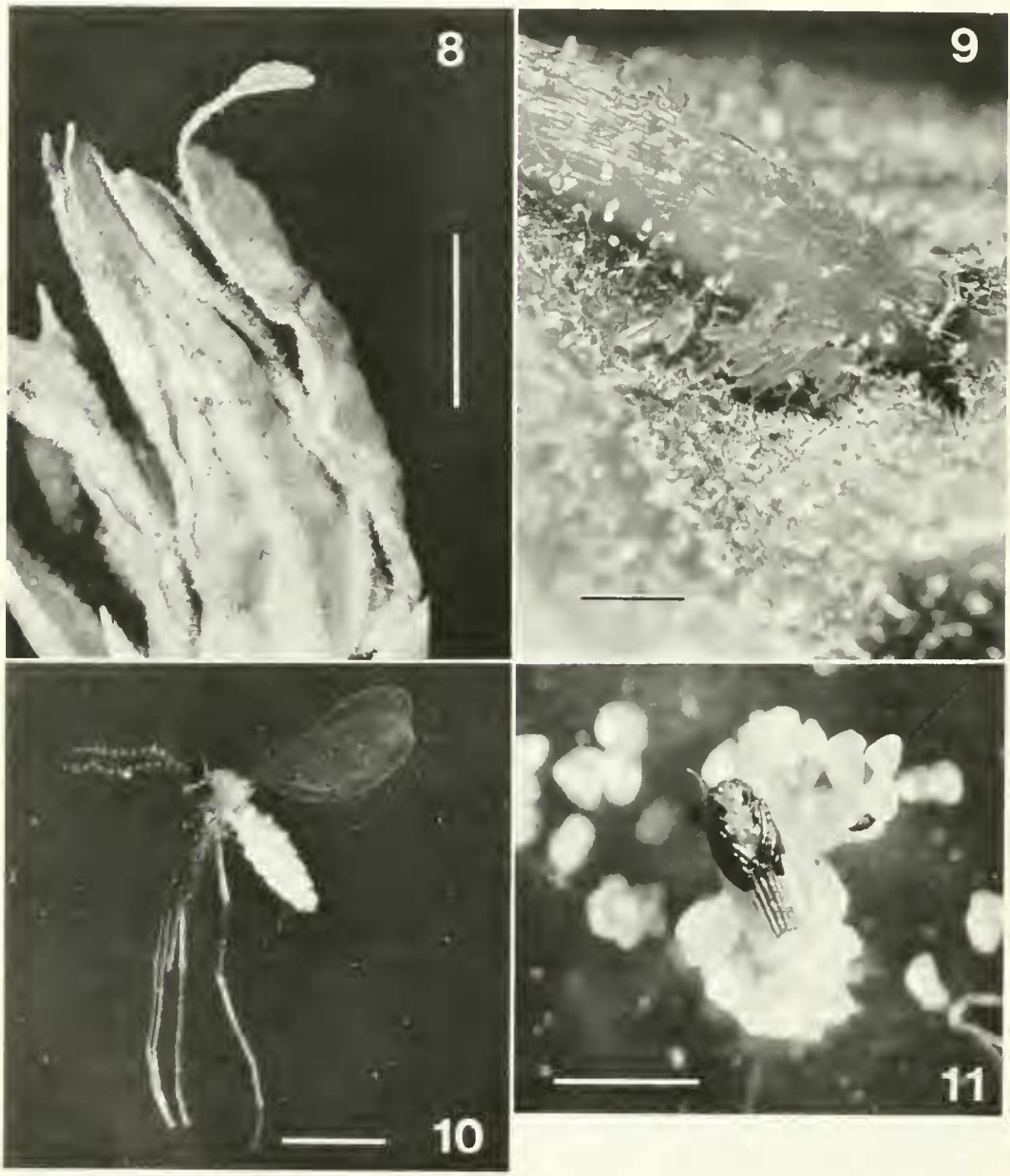
Adult yellowish (Fig. 10).

Life History

Eggs may be deposited on swollen, partly opened, or fully opened vegetative buds throughout most of the growing season but may also be placed on dormant flower buds in early autumn. Clutch size is variable (mean = 6.66, SD = 5.51, range = 1–29, n = 35). Eggs are most often deposited on the undersurfaces or rolled edges of leaves as soon as they are free from the bud but before they have fully separated from each other. Eggs are not deposited in a specific orientation but may adhere to a leaf along their lengths, on end, or obliquely, and are often attached to each other in irregular clumps.

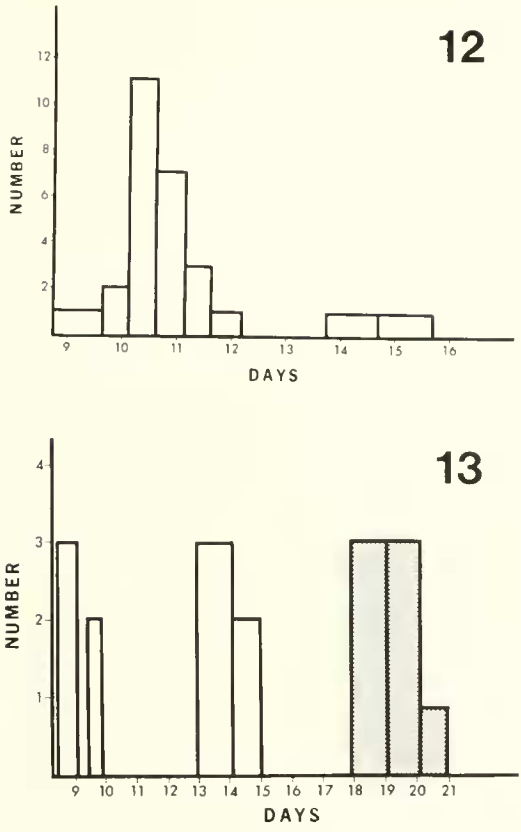


Figs. 3–7. *Clinodiplosis rhododendri* (mature larva). 3, Anterior segments, ventral view (SS = spatula, SR = spinule rows). 4, Posterior segments, ventral view (AN = anus). 5, Head. 6, Mouthparts (LM = labrum, MX = maxilla, LB = labium). 7, Rows of spinules. The barren area within the rows shows the location of an asetose, anterior ventral papilla. Scale bars for Figs. 3, 4 represent 0.25 mm; all others represent 10.0 μm.



Figs. 8–11. *Clinodiplosis rhododendri*. 8, Damage to very young leaves of a *Rhododendron catawbiense* hybrid. Larvae are present in the rolled leaf margins. Note swollen, necrotic areas and necrotic lesions. 9, Eggs on undersurface of an expanding leaf. 10, Adult female. 11, Mature pupa with broken cocoon. Scale bars for Figs. 8, 9 represent 10.0 mm, 0.5 mm, respectively; those for Figs. 10, 11 represent 1.0 mm.

A female may deposit several clutches on the same developing leaf, distribute them among other leaves in the same whorl, or deposit them on different plants. Females readily oviposit on leaves and buds already bearing clutches from other females. In an outbreak situation 272 eggs were found on one swollen vegetative bud. Oviposition was



Figs. 12–13. *Clinodiplosis rhododendri*. 12, Adult emergence following placement of mature larvae in moist sand on day 0. 13, Emergence of *C. rhododendri* (white bars) and *Platygaster* sp. (shaded bars) following placement of mature larvae in moist sand on day 0.

never witnessed during frequent trips to Site 2 between 10:00 AM and 7:00 PM. Eggs hatch in ca. 3 days.

Upon hatching a larva crawls into a loosely inrolled margin of a developing leaf and begins feeding on the abaxial surface; this feeding usually induces a strong inrolling of the leaf margin. Most leaf rolls are moist to wet inside. Larvae that have hatched on swollen vegetative buds crawl into the bud to feed on all surfaces of developing leaves. Larvae infesting flower buds usually feed on the outer bud scales. Larvae do not move from leaf to leaf but are restricted to feeding on the leaf on which they hatched.

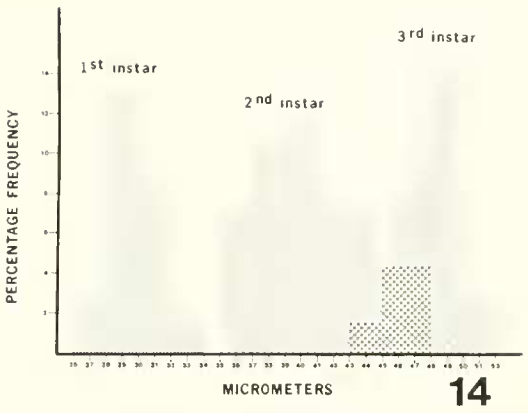


Fig. 14. *Clinodiplosis rhododendri*. 14, Frequency distribution of larval head capsule widths. Note overlap between second and third instars.

Larvae pass through three instars (Fig. 14). Head capsule widths of the second and third instars overlap. The third-instar larva is distinctive, however, due to the presence of the spatula.

All larval stages are motile but require a film of water for sustained locomotion. Larval development takes ca. 7 days. Mature larvae crawl out of damaged leaves or buds and either drop to the ground or descend from the leaves on silken threads (pers. observation). They burrow into the top 2 cm of soil and construct a flimsy, silken cocoon (Fig. 11). Cocoons, which were not found at depths exceeding 2 cm, are covered with soil particles that adhere tightly; in sandy soils cocoons and adhering particles are approximately ellipsoidal, ca. 2.5 mm in length. Larvae moult into pupae ca. 7 days after burrowing into the soil. The mature pupa breaks out of the larval cocoon, probably with the aid of its antennal processes, and wriggles to the soil surface where ecdysis to the adult occurs. Laboratory rearings suggest that ca. 11 days elapse from the time mature larvae drop to the soil until adults emerge (Fig. 12). A few adults emerged at 14–15 days.

Adults emerge during the night or early morning; peak emergence of 27 laboratory-reared adults occurred between 9:00 PM and

8:00 AM. Five adults were observed in the field between 4:50 AM and 6:20 AM on 25 August 1979 at Site 2, but none were seen during frequent visits between 10:00 AM and 7:00 PM. Adults were observed to walk upon plant surfaces with quick, jerky movements. They frequently flew from plant part to plant part. The longevity of adults in the laboratory was ca. 3 days for females and 1 day for males. The sex ratio is female-predominant; 76% of 25 laboratory-reared adults were female. A binomial proportion test (Snedecor and Cochran 1967) indicated that the observed proportions were significantly different from a 1:1 ratio ($\chi^2 = 5.76$, df = 1, $P < 0.025$). Fecundity was variable (mean = 34.5 eggs/female, SD = 11.5, range = 10–51, n = 10).

Throughout this study the only nursery-grown plants observed to be hosts of *C. rhododendri* were hybrids of the Catawba rhododendron, *R. catawbiense* Michaux. All such hybrids observed in the field served as host plants. The two most widely grown hybrids, 'Nova Zembla', and 'Roseum Elegans', appeared to be equally susceptible to attack; a binomial proportion test (Snedecor and Cochran 1967) indicated that the proportion of damaged flower buds was not significantly different for these two hybrids ($\chi^2 = 0.153$, df = 1, $P = 0.70$). *Clinodiplosis rhododendri* was found on wild *R. maximum* at Livingston Manor, Sullivan County, NY during the summer of 1982.

Seasonal History

On 10 May 1980, plants at Site 2 exhibited slight swelling of vegetative buds. Adults, eggs, or larvae of *C. rhododendri* could not be found on any plant part. On 19 May most vegetative buds were swollen (a small number had opened) while flower buds were beginning to swell. A female of *C. rhododendri* was found stuck to a swollen flower bud and a male and female were found stuck to a partly opened vegetative bud. By 24 May many plants were beginning to flower. Although no evidence of *C. rhododendri* was found in a random sample of 25 swollen and opened vegetative buds, an adult was found in an emergence trap for the first time. By 27 May most vegetative buds had opened and leaves were enlarging. Most plants were in full bloom. The number of adults caught in emergence traps peaked at this time (n = 6). Leaves damaged by *C. rhododendri* were first found on 2 June. These contained mostly first-instar larvae but also second and third instars, and in some cases leaves had already been vacated. The last adults from the overwintering generation were found in an emergence trap on 5 June.

Eggs were first observed on 29 May 1980 at Site 2. A single clutch of 16 eggs was found in a random sample of 40 expanding vegetative buds. On 2 June, two buds (of 20 randomly sampled) bore small clutches. Three days later six of 20 buds yielded a total of 120 eggs. Oviposition during this period increased logarithmically (For log % of vegetative buds bearing eggs vs. time, r = 0.993). The observed increase in the magnitude of the infestation could have been due to two phenomena: 1) a prolonged, increasing emergence of overwintering adults, or 2) oviposition by a subsequent, larger generation of gall midges.

On 19 June 1980, a much greater number of mature, brightly colored larvae were noted than had been found previously. Many of these larvae were present in severely damaged leaves that had become necrotic and dry and which thus provided little or no food. On 25 June, only mature larvae occupied the leaves. During this period the weather was dry, the last rain having occurred on 10 June. On 28 June, 10 damaged leaf whorls were randomly sampled for larvae; nine of these had 48 brightly colored mature larvae distributed among them. Eggs or immature larvae were not found. Heavy rain fell on 29 June. The next day a random sample of 10 damaged leaf whorls yielded no larvae of any age. The larvae had apparently been in aestivation in the leaves for at least 10 days. Dry necrotic leaves con-

taining mature larvae were brought into the laboratory and stored in a paper bag under dry conditions for 16 days. At the end of this period larvae were removed from the dried leaves and observed with a dissecting microscope. The larvae were motionless and appeared dead, but with the addition of water began moving. A number of these larvae developed into adults. It appears that free water, such as is supplied by rain, is required for larvae to vacate the leaves. In the prolonged absence of rain, larvae aestivate.

The early seasonal history of *C. rhododendri* is characterized by a close synchrony with the development of its host plant. Adults of the overwintering generation begin to emerge as vegetative buds swell, and peak emergence appears to occur during full bloom. During this time there is no intraspecific competition for the many enlarging vegetative buds as very few insects are present. Subsequent generations of the gall midge more fully utilize the large number of enlarging buds. Intraspecific competition for oviposition sites begins at this time and may continue for the remainder of the season. *R. catawbiense* hybrids usually produce two flushes of growth per season but only the spring flush is seasonally synchronized; the second flush may occur at any time between July and September. The gall midge population, which increases greatly during the spring flush, is faced with a reduced and temporally discontinuous resource for the remainder of the season, resulting in a loss of synchrony between insect and host plant. For example, on 28 June, 272 eggs were found on one of the few remaining vegetative buds present in the nursery.

As autumn approaches, an increasing percentage of the larval population does not pupate following cocoon construction but instead enters diapause until following seasons. Twelve percent of 50 last-instar larvae collected at Site 2 on 25 August 1980 did not pupate. In contrast, all of 20 last instar larvae collected at Site 1 on 26 June 1979 developed into adults within 12 days. On 20 September, almost every plant had completed growth for the season although a few enlarging vegetative buds could still be found. Surprisingly, eggs occurred on these buds. Based on field observations and laboratory rearings, by this time five generations of the gall midge may have developed. On 14 October 1979, mature and penultimate-instar larvae were found although most of these were in necrotic, dry leaves and probably were not feeding. An examination of dormant flower buds revealed small necrotic lesions in the outer tissues of some buds. A few of these damaged buds contained mature larvae. Oviposition had apparently occurred on these flower buds in the absence of suitable vegetative buds, and some of the larvae had matured and dropped to the soil to overwinter. Mature larvae remaining in flower buds would be expected to overwinter there because of the time of year and their marked inactivity. A random sample of 53 flower buds taken on 10 April the following spring contained a total of 12 larvae, five of which were alive. Seventeen buds showed evidence of damage. Four of the living larvae were found in one bud.

Natural Enemies

No natural enemies of *C. rhododendri* have been previously identified. Field and laboratory observations suggest that natural enemies are relatively insignificant as control agents during most of the seasonal history of the insect. A random sample of 40 mature larvae collected at Site 1 on 25 August 1979 yielded only two parasitized individuals. No other incidences of parasitism or predation were observed at Site 1. The effect of natural enemies was greater at Site 2, but appeared to be confined to the late seasonal history of the insect.

A male pteromalid, possibly of the genus *Callitula* Spinola, was reared from an ectoparasitic larva found on a mature gall midge larva collected on 25 August 1979 at Site 1. The adult parasitoid eclosed ca. 9

days after the gall midge larva was placed in moist sand, or ca. 1 day before the peak emergence of the gall midge cohort. The parasitized larva failed to construct a cocoon or pupate.

Two male parasitic wasps of the genus *Platygaster* Latreille were reared from a mature gall midge larva collected on 25 August 1979 at Site 1. The platygasterids were endoparasitic, and pupated in a head-to-head position within the cuticle of their host. The parasitized larva successfully constructed a cocoon. The parasitoids emerged ca. 8 days after the peak emergence of the gall midge cohort.

A single encyrtid wasp, probably of the genus *Copidosoma* Ratzeburg, emerged from a sample of infested leaves collected on 26 August 1980 at Site 2. A pteromalid, possibly of the genus *Mesopolobus* Westwood, was also recovered from the same sample.

A species of *Platygaster* was commonly recovered from mature larvae collected on 26 August 1980 at Site 2. Ten of 30 gall midge larvae in one sample and 15 of 50 in another were parasitized by this wasp. In all cases one individual pupated per host, in contrast to the *Platygaster* sp. reared from Site 1, where two individuals pupated within one larva.

Sixteen of 25 parasitized larvae successfully constructed cocoons, although all died shortly thereafter. All of the parasitoids emerged after the peak emergence of the gall midge cohort (Fig. 13).

The anthocorid bug *Orius insidiosus* (Say) was abundant in infested leaves collected on 26 August 1980 at Site 2. It was probably feeding on mature larvae present in the leaves, although feeding was not observed. No other predators were observed.

Infestation and Damage

The rhododendron gall midge is an occasionally serious, but not commonly encountered pest in nurseries on Long Island. It has not been reported to be a pest in home plantings.

The distribution of this insect at both study sites was strongly clumped. At Site 2, groups of non-infested and very lightly infested plants could be found within 10 m of heavily infested ones. Five emergence traps were placed 2–3 m apart in a 72 m^2 bed of 4-yr old plants on 25 June 1980. Three days later the number of adults in each trap was as follows: 4, 0, 1, 0, 156. Barriers such as woods, fence rows, and non-host plantings seem to limit infestations. The infestation at Site 1 was limited to a 2-ha field of stock plants. A large number of container-grown plants, separated from the infested field by ca. 275 m of wooded fence-rows and non-host plantings, were not infested. It appears that the active dispersal capability of this insect is small.

Infestations usually remain at a low level, but under favorable conditions can increase dramatically. A 72 m^2 bed of 2-yr old plants growing in a screen house at Site 2 was infested so severely that no growth occurred, resulting in the destruction of the plants by the nurseryman.

Serious infestations of the rhododendron gall midge tend to be short-lived. This may be a function of variables such as rapid turnover of nursery-grown plants, use of insecticides, adverse environmental conditions caused by weather and cultural practices, and natural enemies. The owner of the nursery at Site 1 first noticed gall midge damage in 1976. The severity of damage increased each year until 1980, when it was markedly diminished. Various insecticides were applied to the plants during this period. The owner of the nursery at Site 2 first noticed damage in 1979. Severity increased greatly in 1980. The insecticide diazinon, applied as a soil-drench in the spring of 1981, reportedly gave good control of the pest. Whitman Wholesale Nurseries, Suffolk Co., NY, sustained damage by this pest on container-grown plants in 1978. The insecticide lindane was applied to the plants three times during the year. The gall midge could not be found at this nursery in 1979.

Various types of damage may result from the feeding of *C. rhododendri* depending on the number of larvae present and the development stages of affected parts. Leaves that are heavily attacked while still in the bud are severely damaged and normally die before attaining a length of 6 cm. Leaves thus affected exhibit swollen, chlorotic areas and necrotic lesions (Fig. 8). Leaves attacked while free of the bud may reach full size but become deformed. On these leaves small (ca. 1 mm^2), chlorotic lesions are produced in affected areas. All infested leaves develop an inrolling of one or both margins and become contorted. Damaged areas of leaves become necrotic with time. Larvae feeding within flower buds produce necrotic lesions in the outer bud tissues.

Discussion

Bionomics: The biology of *C. rhododendri* is similar to that of the leaf-curling pear midge, *Dasineura pyri* (Bouche). Both species are multivoltine, oviposit on newly expanding leaves, cause leaf margins to roll on woody plants, and overwinter as mature larvae in the soil (Barnes 1935). The tendency toward restriction of emergence, mating, and oviposition activities of gall midges to the night and early morning hours has been reported by many workers, including Weigel and Sanford (1920), Walter (1941), and Coutin and Harris (1968). This restriction of adult activities is advantageous for at least two reasons: 1) it minimizes the disruptive effects of wind, the primary dispersal agent for the higher gall midges (Mamaev 1968), and 2) it minimizes the potential for desiccation, especially during emergence. The short adult life of *C. rhododendri* is common to other cecidomyiids (Weigel and Sanford 1920, Walter 1941, Azab et al. 1965, Brewer 1971, Ranasinghe 1977). Another aspect of the biology of *C. rhododendri* that is shared by other cecidomyiids is a female-predominant sex ratio (Sasscer and Borden 1919, Barnes 1935, Walter 1941, Redfern 1975, Ranasinghe 1977). *Clinodiplosis rhododendri* appears to be native to the northeastern United States as it has been found on wild *R. maximum* in both the Catskill mountains of New York and the Pocono mountains of Pennsylvania. It has not been recorded to occur outside of this area on a wild host, nor has it been recorded from any other wild host. It has been found on cultivated hosts in nurseries from Maryland north to Massachusetts. *R. maximum, R. catawbiense, R. ponticum, R. caucasicum* Pallas, *R. arboreum* Smith, and *R. smirnowii* Trautvetter are all reported to be parent species of *R. catawbiense* hybrids. *C. rhododendri* has been reported to occur on *R. ponticum* in nurseries (White 1933).

Phenology: The seasonal history of *C. rhododendri* is similar to that of other cecidomyiids. The emergence of adults in spring coincides closely with the development of their host plant. Synchrony between gall midges and host plants has been reported by Bishop (1954), Gable et al. (1959), and Coutin and Harris (1968). Coutin (1964) reported that for many species the behavior of ovipositing females and the duration of oviposition are governed by the floral biology of the host. The seasonal buildup of large populations of *C. rhododendri* is common to other gall midges as well. Barnes (1940) reported that over 2000 individuals of *Diarthronomyia chrysanthemi* Ahlberg may develop in one chrysanthemum plant. The number of larvae of *Contarinia pseudotsugae* Condrashoff developing in a single Douglas-fir shoot is usually over 2000 (Condrashoff 1962). The aestivation of mature larvae of *C. rhododendri* during dry weather also resembles the behavior of other gall midges. Bishop (1954) reported that mature larvae of *Dasineura gentneri* Pritchard remain in clover florets for variable intervals, dependent on weather conditions. During damp or rainy weather there is a tendency for the larvae to vacate the florets shortly after reaching maturity. During dry weather some larvae may remain in the florets for a week or more. Barnes (1952b) showed that

fully fed larvae of *Contarinia tritici* (Kirby) need moist conditions in order to descend from damaged wheat plants to the soil. Dry weather during the maturation of larvae results in an assemblage of larvae in damaged plants that vacate the plants en masse when rain comes. These same conditions are required by *C. rhododendri*. Diapause of mature larvae during autumn and winter is a common aspect in the seasonal history of many gall midge species, including *C. rhododendri*. Barnes (1935) noted that in the multivoltine species *D. pyri*, varying proportions of the larvae of the second, third, and fourth generations entered diapause until the following spring. He also demonstrated that larvae of *C. tritici* could spend two winters in diapause, those of *Sitodiplosis mosellana* (Gehin) three winters (Barnes 1943), and later (Barnes 1952a) showed that *S. mosellana* may diapause for up to 12 years. The late season utilization of flower buds as an alternate resource by *C. rhododendri* appears to be unrecorded for other cecidomyiids.

Natural enemies: Species of *Platygaster* have been recorded from other cecidomyiids by a number of workers (Brewer 1971, Coutin and Harris 1968, Houseweart and Brewer 1972, and Ranasinghe 1977). Most platygasterids are parasitoids of cecidomyiid larvae (Borror et al. 1976). Both Coutin and Harris (1968) and Barnes (1935) observed predation of gall midge larvae by Anthocoridae.

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